FORESTRY and DEER

in the Pine Region of New Jersey

by
S. Little
G. R. Moorhead
H. A. Somes

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RALPH W. MARQUIS, DIRECTOR

About the Authors . . .

SILAS LITTLE *received his B.S. degree from Massachusetts State College in 1935, his M.F. in 1936 and Ph.D. in 1947 from Yale University. An employee of the U.S. Forest Service since 1936, he has worked chiefly on forest-management research in southern New Jersey and eastern Maryland. At present he is in charge of the Coastal Oak-Pine Research Center of the Northeastern Forest Experiment Station, New Lisbon, N.J.*

GEORGE R. MOORHEAD *received his B.S. degree in forestry from Pennsylvania State College in 1933. He was a foreman in the Civilian Conservation Corps in New Jersey until 1941, when he joined the forest-management staff of the New Jersey Department of Conservation. In 1957 he became Chief of the Department's Forest Management Section.*

HORACE A. SOMES *graduated from the Pennsylvania State College Ranger School in 1932. For a short time he was employed on the New Jersey state forests, and then was a foreman in the Civilian Conservation Corps until 1942. Except for military service in World War II, he has since served as a forestry aid at the Coastal Oak-Pine Research Center of the Northeastern Forest Experiment Station.*

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A summary of our present knowledge of the relationships between forestry and deer, and the need to attain a balance — a deer herd managed to prevent damage to timber production, and sustained forestry practices to provide a steady supply of food for deer.

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Forestry and Deer

FORESTRY and deer affect each other's welfare. Forestry and other land-use practices, particularly farming, affect deer chiefly by modifying the supplies of available food and protective cover. On the other side, an overabundance of deer can overbrowse and eliminate the most palatable and nutritious food species. If these are trees that could be valuable for timber, the amount and value of future timber crops can be greatly reduced. If this happens, forestry may become impractical; and then an important natural resource may be sacrificed to deer (Latham 1950).

The balance between forests and deer is a concern in the Pine Region of southern New Jersey, an area of some 2,000 square miles, most of it forested, where forestry is an important land-use practice that may affect, and be affected by, the abundance of deer found there.

The New Jersey Pine Region--also called the Pine Barrens--lies in the eastern portion of the Coastal Plain (Moore 1939). It extends roughly from the vicinity of Asbury Park southward into the upper part of Cape May County (fig. 1).

Here quail, rabbits, squirrels, ruffed grouse, raccoons, and foxes are also found. However, only deer (*Odocoileus virginianus*) are considered in this report because they, of all the wildlife, exert by far the greatest influence on their forest habitat. Also, it is on the deer herd that hunters and agencies concerned with wildlife management have focussed attention.

The Pine Region could produce both timber and deer in a balanced program. This would call for a deer herd managed to prevent damage to timber production, and forestry practices that provide a steady supply of food for deer.

The purpose of this paper is to summarize our present knowledge of the relationships between forestry and deer in the Pine Region. It is based on observations and studies made since 1928. The results are presented to show first the food habits of deer in different seasons on different sites, and then the relationships between deer and forest management.

Food Preferences of Deer

DORMANT SEASON

Woody browse is most important to white-tailed deer in the Pine Region during the period of dormant plant growth that extends from mid-October to late April or early May when ferns and herbs start new growth. This region has few cultivated fields, and thus hardly any green cover crops, such as winter rye, are then available. Deer eat some acorns, particularly early in autumn. They crop a few herbaceous plants, such as pinweed,[1] which has a green basal rosette overwinter. But so rarely are herbaceous plants eaten that they are of little value. Also, an occasional piece of moss, lichen, or toadstool may be consumed; but observations here and studies elsewhere, such as that by Korschgen (1954), show their unimportance. Thus woody browse, the most readily available food, makes up the bulk of deer diet during this season.

Upland Sites

Pines.--Relatively young pine shoots provide most of the winter browse on upland sites. All three native species are browsed. In one area where all three species occurred, 32 percent of the Virginia pine reproduction, 50 percent of the shortleaf pines, and 65 percent of the pitch pines had been browsed (Little 1937). Observations in other areas in-

[1] Scientific names of plants are listed in the Appendix.

dicate that deer have little preference between shortleaf pine and pitch pine, the two most common species.

Deer browse mostly on the small pine shoots (fig. 2). In the spring of 1949, four groups of 50 seedlings each were examined in a slash-free cutover area. Each group was composed wholly of seedlings in one of the following diameter classes: 1/16-inch, 2/16-inch, 3/16-inch, 1/4-inch or more. Diameters were measured about 2 inches below the terminal bud on undamaged seedlings or at the point of injury if the terminal had been browsed since the previous growing season. Deer had browsed 84 percent of the seedlings that had shoots 1/16-inch in diameter, 70 percent of those in the 2/16-inch class, 30 percent of the third class, but only 8 percent of the trees with the largest shoots (Little and Somes 1949).

The size of trees damaged depends partly on whether they grow under shade or out in the open. Shade-grown seedlings have smaller shoots than open-grown seedlings of the same height. Shade-grown reproduction was examined on 196 1/100-acre plots located at fixed intervals in a 4-acre area. These plots were away from any extensive cuttings. Trees were classed as heavily injured if their leaders had been browsed or if, as a result of browsing, the trees appeared misshapen or stunted. Pines in all size classes up to 1 inch d.b.h. (diameter at breast height) had been browsed. But heavily injured trees included 43 percent of those 0.6

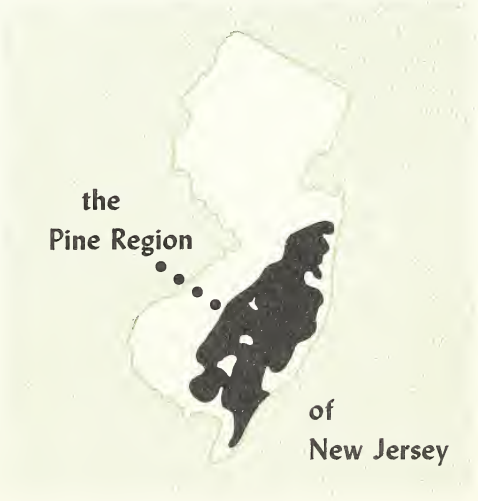

Figure 1.
The Pine Region of New Jersey. Here a need is felt for a better balance between forestry and deer.

to 1.5 feet tall, and only 1 percent of the trees more than 4.5 feet tall (Little 1937).

Open-grown pines more than 2 feet tall are not usually browsed this way. For example, all stems were examined on 0.15 acre in a cutover area where pine seedlings occurred at the rate of 5,600 per acre. There, during the previous winter, deer browsed the leaders on 64 percent of the stems 0.1 to 1.0 foot tall, and on 5 percent of the

Figure 2.--*A pitch pine seedling that deer have browsed repeatedly. Note the dead stubs, 16 in all, created by deer clipping a shoot or branch. The lowest is only 2 inches above the root collar, where this stem was cut. The photograph was taken in the early fall, one growing season after the last browsing damage.*

seedlings 1.1 to 2.0 feet tall. But no damage to terminal shoots was found on trees more than 2 feet tall.

Extent and duration of browsing damage seem related to the amount of pine reproduction as well as growing conditions. On a 40-acre area that had been cut over 6 years before, it was observed that: (1) trees were more severely damaged in plots with small amounts of pine reproduction than in those with large amounts; and (2) pines suppressed by bear oaks, and thus spindly and small, were repeatedly browsed for a longer period than more vigorous ones growing between clumps of tree-oak sprouts.

To obtain a more complete picture of the effect of deer on pine reproduction, twelve 1/40-acre plots were established in cutover upland areas in the Lebanon State Forest between 1949 and 1952. Six plots were fenced to exclude deer; adjoining each of these was a comparable plot left unfenced. Results to date from these plots are as follows:

- Deer do little damage to pines more than 1 foot tall. When open-grown, only a few of these pines are browsed, usually only on the side branches, so height growth is not appreciably affected.

- Deer may greatly reduce the height growth of smaller seedlings. Seedlings present when the fences were erected, and undamaged thereafter, grew as much as 1 foot more in height in 5 years than did similar seedlings whose terminals were browsed once. When leaders were clipped two or more times in 5 years, height growth frequently was 2 to 4 feet less than for comparable undamaged stems. Repeated browsing occurred chiefly on seedlings that were less than 0.6 foot tall when the study started.

- Browsing increased the mortality of pines that survived their first growing season--by 25 to 55 percent during the following 2 to 4 years.

The amount of damage varies with the number of deer. In the Belleplain State Forest, which had a low deer population, no browsing damage was observed in a series of reproduction plots in 1947, 7 years after seedbed treatment. But in the Lebanon State Forest, which had a higher deer population, 20 to 40 percent of the pine seedlings in a similar series of plots had been injured. Earlier censuses (1938-1940) indicated that deer were present at the rate of 1 to

every 50 acres where the 20-percent damage was subsequently observed, and at the rate of 1 to every 10 acres where the 40-percent damage was noted (Little and Moore 1952).

Hardwoods.--Principal species of hardwood trees on upland sites are oaks--black, white, chestnut, post, and scarlet. Other species such as red maple, hickories, and southern red oak are relatively rare, occurring mostly in stands near the edges of the Pine Region. All these hardwoods are rare in areas that have been frequently burned by killing fires. There the principal hardwoods are shrub oaks, usually bear oak, but often some blackjack oak and dwarf chinkapin oak.

In Pennsylvania, Bramble and Goddard (1953) found that scarlet, white, black, and chestnut oaks were browsed more in the winter than scrub (bear) oak. Observations in the Pine Region also show that tree-oak sprouts are more palatable than bear oak. In fact, hardly any winter browsing has been observed on 1-year-old sprouts of bear oak, while similar sprouts of any of the tree oaks are usually nipped. But deer take only the top few inches of an oak sprout unless the shoots are extremely succulent or other food is scarce.

Consequently, oak and pine browse do not usually form a large concentrated supply of food for deer. In October 1952, the lengths of shoots on sprouts and seedlings of both oaks and pines were measured on 50 milacres (1/20-acre) in an area on the Lebanon State Forest that had been cut over the previous winter. Most of the pines were seedlings, the majority being 1 year old, and many were only 0.1 to 0.3 foot tall. The oaks were mostly sprouts, but there were several seedlings less than 1 foot tall, chiefly black oak and a few white oak.

A retally in the spring showed that overwinter the deer took 13 linear feet of pine browse and 23 feet of oak browse. This amounted to 21 percent of the available pine shoots and 8 percent of the oak shoots. On the basis of two 1-foot samples collected from shoots similar to those browsed, pines in this area furnished 3.3 pounds of green browse per acre; the oaks, 3.85 pounds per acre.

In an adjoining area, cut over earlier, no recent evidence of browsing was found on 4-year-old oak sprouts,

although small pines were still being browsed. The relatively slow-growing oak seedlings were browsed hardly at all, even though pines of the same size were being cropped.

Observations show that, after timber cutting or killing fires, tree-oak sprouts furnish the most food the first year, lesser amounts the second and third years, and practically none thereafter. The most browse from pine reproduction is usually available during the same period, but in many areas some is still being obtained 5 years or more after cutting.

Still, the volume of browse produced on upland sites is not sufficient to support many deer. According to Trippensee (1948), a white-tailed deer probably consumes 4½ to 7 pounds of green browse per day during the winter. Thus, pine and oak reproduction in the recently cutover area mentioned above, though furnishing far more browse than uncut stands, still could support relatively few animals. Probably in 2 years or so the pine reproduction there would be furnishing the maximum amount of food--some 30 pounds or more per acre, or enough on 14 acres to carry one deer for 3 months. But that would be the maximum available during the life of the timber crop, so the bulk of the food for the present deer herd must come from upland shrubs or from lowland areas.

Upland shrubs.--Other than scrub oaks, the chief upland shrubs are huckleberries and lowbush blueberries. Less common are such shrubs as sweetfern and hawthorn. Huckleberry is seldom taken by deer, and blueberry only slightly, according to surveys made on 500 milacre-quadrats (0.5 acre) in different upland areas in the Lebanon State Forest. That conclusion agrees with studies by Bramble and Goddard (1953) and Korschgen (1954). Bramble and Goddard found sweetfern to be browsed heavily in one area, but only lightly in another.

All evidence indicates that upland shrubs furnish little winter food for deer in the New Jersey Pine Region, much less, in fact, than does tree reproduction.

Lowland Sites

Although lowland sites cover only about a third as much area as upland sites in the Pine Region, all available data and observations indicate that much of the deer's food comes from these lowlands. There dense growth offers both excellent cover and food.

White-cedar.--Atlantic white-cedar is apparently the favorite browse of deer in this section: it provides most of their winter food on lowland sites. At least the authors' observations have revealed no other species that is so intensively browsed and supplies so much volume and weight of winter browse. A taxidermist in Medford, New Jersey, told the authors that white-cedar foliage formed the bulk of the stomach contents in the local deer he had examined.

That white-cedar is heavily browsed is shown by research data and observations made in different parts of the Pine Region.

- Two 0.1-acre plots, one fenced and one unfenced, were established in 1941 in a relatively dry swamp near the Lebanon Glass Works in the Lebanon State Forest. The area then had more than 27,000 white-cedar stems per acre between 0.5 and 2.5 feet tall. These were mingled with many shrubs and some pitch pines. On 119 stocked ¼-milacre quadrats of the 120 examined, only 8 percent of the tallest white-cedars had not been browsed. In the following 16 years, repeated browsing prevented unprotected white-cedars from gaining more than 0.5 foot in height. Comparable trees in the fenced plot grew much faster, but still the largest were only 4 to 10 feet tall in 1957. The slow recovery of protected trees apparently was due to two factors: (1) layering, as a result of past browsing, had created clumps of as many as 15 stems that drew on the same root system; and (2) the site was too dry for the best growth of white-cedar (Little 1950).

- Two 1/160-acre plots, one fenced and one unfenced, were established below Chatsworth in 1955. These were in a swamp where a white-cedar stand had been killed by a 19,500-acre wildfire in July 1954. Even though that fire created a large amount of fresh browse nearby, deer severely damaged white-cedar reproduction in the unfenced plot. A year after the fire this plot had 111,520 white-cedar seedlings per

acre; 2 years later it had only 11,360--a drop of 90 percent compared to a 43-percent loss in the fenced plot. In those 2 years the number of ¼-milacre quadrats stocked with white-cedar seedlings did not change in the fenced plot, but decreased 20 percent in the unfenced plot. In 1957 the average height of crop trees (largest 1,600 trees per acre) was 3 feet where protected from browsing, while only 1 foot where unprotected. And the maximum height of protected seedlings was 4.4 feet; of unprotected seedlings, 1.4 feet.

● In Stop-the-Jade Run, Lebanon State Forest, ten 0.1-acre plots were established in a hardwood swamp, and white-cedar seedlings were planted after various treatments to the hardwood overstory. The planted stock had a survival of about 100 percent at the end of the first growing season, but were browsed so heavily during the following winter that many died. Even in the control plots, 97 percent of the seedlings were injured during the first winter and mortality on the open areas approached 50 percent by the end of the second growing season. Under all treatments, surviving seedlings were then 0.3 to 0.5 foot shorter on the average than at the end of the first growing season. One striking example was a seedling 0.5 foot tall when planted, 1.8 feet tall at the end of the first growing season, but only 0.3 foot tall at the end of the second summer. Most of the reproduction could not survive under such severe browsing, and by the end of the second winter nearly all the seedlings had died.

● Near the head of Paradise Branch in the Lebanon State Forest, a rather open area stocked chiefly with shrubs was seeded to white-cedar in 1936 by CCC crews. When examined in 1954, 18 years later, the area had only a few surviving white-cedars that might outgrow deer browsing. A few seedlings were found that had recently died after repeated browsing, and several had been browsed so frequently that they will probably die soon. Deer seem to be the principal cause for the almost complete failure of this seeding.

● At the head of Shinns Branch there is also an open area where only a few white-cedars, 2 to 5 inches d.b.h., top the shrubs. But around them there are natural seedlings that might form a stand if deer browsing were not a factor. Age counts on a few of these white-cedar seedlings--2 to 3 feet tall--showed that some of them are 25 to 30 years old, or about 15 years younger than the stems 2 to 5 inches in

Figure 3.--*Browse line on Atlantic white-cedars. Though not common, such browse lines are seen occasionally, always on scattered white-cedars growing in areas where other vegetation is only 2 or 3 feet tall. Here the smaller growth, chiefly leatherleaf, also includes repeatedly browsed white-cedar reproduction.*

diameter. Again repeated browsing of seedlings has caused the failure of white-cedars to form a complete stand.

- Similar retarding effects from repeated browsing of white-cedars have been observed near Upper Mill, along the edges of Shinns, McDonalds, South, and North Branches in the Lebanon State Forest, in an abandoned cranberry bog below Hog Wallow, and in the Penn State Forest. In those areas the damage has been so heavy that browse lines have developed on saplings and pole-size trees (fig. 3), or reproduction has remained about the same size for several years.

- Near Lakehurst more than 10 acres of white-cedar swamp were cut over in 1946 and 1947. In 1950 the area had

excellent natural reproduction of white-cedar, but browsing by deer was very heavy. Many small seedlings were uprooted by the browsing deer. Four years later much of the white-cedar reproduction had vanished; the remainder was being severely browsed, leaving hardwoods and shrubs to form most of the next stand.

Deer populations and, consequently, deer damage may vary appreciably within a few miles. In 1954, severe browsing of reproduction and feeding on cut tops of white-cedar were noted in one area being cut over along Teal Creek, Atlantic County; while in another cutting area, 3 to 4 miles away near Weekstown, little evidence of deer browsing was observed.

Generally much of the browsing is done in the drier swamps or on the edges of wet ones where the footing is better. However, when little white-cedar browse is available, or when deer populations are high, deer do heavy damage in wet swamps such as the areas in Stop-the-Jade Run, near Lakehurst, and along Teal Creek.

Just how much browse deer can obtain in reproduction stands of white-cedar may not be fully appreciated. By clipping and weighing all suitable browse on 8 white-cedars, 2 in a height class, and by sample tallies of trees by height classes, the authors estimated a total of 3 tons of green white-cedar browse per acre in one well-stocked stand of white-cedar reproduction (table 1).

Table 1.--White-cedar browse available to deer in a reproduction stand

Height of trees (feet)	White-cedars per acre	Total amount of browse per acre
	Number	Pounds
6.1 - 10	1,280	912
2.6 - 6.0	14,400	3,819
1.1 - 2.5	43,200	1,295
0.26 - 1.0	55,200	207
Less than 0.26	43,600	--
All sizes	157,680	6,233

The data in table 1 do not include browse available in hardwoods (about 6,700 small stems per acre), shrubs, and other plants. And of course if the total amount were used by deer, the plants would soon die. If 20 percent of the available browse were taken, the area would still furnish about 1,200 pounds of white-cedar browse per acre, or probably enough in 3 acres to feed 4 deer overwinter. Still, where white-cedars are fewer, very small or very large, the amount of available browse decreases.

It is not known whether Atlantic white-cedar is a preferred food because of nutritive values similar to those of northern white-cedar or for other reasons. Davenport (1937) showed by feeding experiments that northern white-cedar was the only native browse in Michigan that, fed alone, would support deer in winter.

Pine.--Pitch pine occurs to a minor extent in true swamps, but it is the predominant tree species on the imperfectly and poorly drained soils of the flats around these swamps. Observations indicate that, where growing with white-cedar, pitch pines are not appreciably browsed. But on the flats, pine seedlings and young sprouts may be closely browsed for winter food.

There the pine seedlings and young sprouts suffer damage similar to that found among the pines of upland sites; that is, old seedlings and sprouts are not touched, while younger ones may be closely cropped. Hence the browsing damage is concentrated particularly in recently cutover or burned areas. If the deer population is fairly high, most of the new seedlings and sprouts may be clipped. These conclusions are based on the following observations:

- In September and October 1951 about 240 acres were burned near Retreat. Tallies the following summer showed 200 to 22,800 new pine seedlings per acre, the number depending on the site and the intensity of the burn (Little and Moore 1953). In the spring of 1953, even in areas where there were more than 6,000 pine seedlings per acre, deer had cropped an estimated 80 percent of them during the previous winter. Most of the larger seedlings that had escaped injury had been protected by dead fronds of bracken fern or by slash.

- In July 1947 a wildfire burned about 3 acres along North Branch in the Lebanon State Forest. Tallies made in the area at the end of the 1949 growing season showed more than 3,500 pine seedlings per acre, many 4 to 8 inches tall, and a few 12 inches tall. In the next 4 years, browsing by deer reduced the number of seedlings and, with intense competition of shrubs, so retarded the growth of surviving seedlings that in 1953 the largest were only 2 feet tall. Of 50 seedlings examined then, terminal shoots on 76 percent had been clipped since 1949, some two or three times.

- Less severe damage has occurred in some larger wildfire burns. Three pairs of 1/40-acre plots, fenced and unfenced, have been established: one pair below Atsion in a 3,600-acre burn of September 1953; two pairs in the 19,500-acre Chatsworth burn of July 1954. In the unprotected plot near Atsion, deer have clipped the terminal shoots on 71 percent of the surviving seedlings, on some of them two or three times between 1954 and 1957. In the Chatsworth plots, deer damaged the terminals on 18 to 38 percent of the unprotected seedlings between 1955 and 1957. Height growth of crop trees in the least damaged plot apparently has not been affected. But where 38 percent of the seedlings were clipped, crop trees (at the rate of 600 per acre) were 0.4 foot shorter in 1957, 2.2 feet compared to 2.6 feet tall in the control.

Hardwoods.--The three predominant hardwood trees on lowland sites are red maple, blackgum, and sweetbay. Red maple is the fifth most important winter food of deer in Massachusetts, and blackgum is also browsed (Van Dersal 1938). Bramble and Goddard (1953) stressed the importance of red maple in Pennsylvania, and pointed out that their findings agreed with those of other investigators working in similar types. However, Stegeman (1937) rated both red maple and blackgum only midway in palatability among the hardwoods he studied in North Carolina. And Korschgen (1954) found blackgum was relatively unimportant in the diet of deer in Missouri.

Observations made in the Lebanon State Forest show that all three swamp hardwoods are browsed, mostly the new sprouts during or at the end of the first growing season. Some trees are not closely browsed: only a few inches of a

sprout are taken. Others, particularly red maple and sweetbay, may be clipped back to a foot or two in height. Small amounts of browsing have also been observed on recent growth of older sprouts and seedlings.

However, none of these hardwoods are so closely browsed for such a long period as white-cedar reproduction. And so, probably as a result of differences in degree of browsing, blackgums, first of all, then red maples and sweetbays, can be found standing up above dense white-cedar reproduction in some areas, particularly along the edges of swamps (fig. 4).

Other plants.--During the dormant season, deer feed to some extent on many shrubs and vines in the lowlands of the Pine Region, also eating an occasional piece of moss, lichen, grass, or sedge. Although deer may cause extensive damage to cultivated highbush blueberries in unfenced fields,[2] only light browsing, particularly of new growth, has been observed on wild highbush blueberries and on other native shrubs--pepperbush, bayberry, and huckleberries. None have been so severely clipped as tree reproduction.

From our observations and the available literature we judge that none of the native vines (swamp blackberry, cranberry, greenbrier, grape, Virginia creeper) are an important source of winter food. Thus, indications are that all these plants other than trees form a very minor part of the deer's total food consumption during the winter.

GROWING SEASON

April To Late August

As new growth starts in the spring, the diet of deer changes to include more nonwoody growth. Deer begin to graze with the first appearance of lush new grasses and other herbs; and they continue to graze till autumn as long as these plants are palatable (Trippensee 1948).

[2]According to a personal communication from C.A. Doehlert of the Cranberry and Blueberry Research Laboratory of the New Jersey Agricultural Experiment Station, New Lisbon, N.J.

Figure 4.--*On the edges of many swamps, deer browsing favors pitch pine, blackgum, red maple, sweetbay, and shrubs over the more severely clipped white-cedars. Although there is abundant white-cedar reproduction among other vegetation on the edge of this white-cedar stand (seen on the right), repeated browsing has kept most of the white-cedars small, like the seedling in front of the cardboard.*

In October 1952, minor vegetation was studied on 500 milacre-quadrats (0.5 acre), located along 50 1-chain lines in different parts of the Lebanon State Forest. On 28 percent of these lines, the ubiquitous blueberries had been browsed, but for the most part only lightly. Bramble and Goddard (1953) found that, in one section of Pennsylvania, blueberry was lightly utilized during all seasons.

Some plants are browsed more heavily than others, despite relative abundance or scarcity. For example, false

foxglove was found on only 24 percent of these lines, but on 75 percent of them it had been browsed--usually heavily (7 times out of 9). Other herbs that had been cropped, usually lightly, were sedge, broom-sedge, hoary pea, and wild indigo. In contrast, the few sassafras and dwarf sumacs present were often moderately to severely browsed.

All data and observations by foresters in this region indicate that most of the deer's diet in summer, as in winter, is obtained on lowland sites. Among lowland vegetation cropped by deer during the growing season are blue flag, turkeybeard, and various swamp grasses, sedges, reeds, and ferns. In spots where deer concentrate, many of these plants are browsed closely.

Deer may also feed extensively on grasses and sedges in cranberry bogs, mostly early and late in the growing season. A part of cranberry culture is to retain water some years on the bog until early July. During those years no cranberry fruit is produced, but the growth of grasses and sedges is succulent later into the fall. Thus attracted, more deer are found in these bogs than in those drained earlier to produce fruit.[3]

Bramble and Goddard (1953) noted that in Pennsylvania many woody plants were browsed during the spring and summer. Among those plants they listed were the following ones that are found also in the Pine Region: Juneberry, greenbrier, sassafras, Virginia creeper, sweetfern, spicebush, huckleberry, blackberry, grape, wild rose, bear oak, dwarf sumac, and blueberry, and also several trees such as oaks and blackgum. According to our observations, these plants are also utilized in New Jersey during this period, most of them only lightly, although in deer-concentration spots, shrubs, vines, and occasional small hardwood sprouts or seedlings may be browsed severely.

For the most part, deer rarely eat tree growth during the growing season. Sometimes before herbs, vines, and shrubs have started much new growth, a little browsing on trees is observed--as on tree seedlings that had been recently planted. Browsing on tree sprouts has also been observed during the growing season in recently cutover areas

[3]Personal communication from Joseph H. Palmer, a cranberry grower, of Tuckerton, N. J.

and especially in areas burned by killing fires the previous spring. Most sprouts nipped then are hardwoods, red maple and sweetbay especially, and tree oaks more than bear oak.

However, if herbaceous growth is scarce in an area, deer may browse fresh sprouts of bear oak and pitch pine. For example:

- On survey lines cut early in the summer of 1952 through an old stand of pitch pine and bear oak near Buckingham on the Lebanon State Forest, most of the resulting sprouts (bear oak) were nipped that summer while still young and succulent. Browsing on these long young sprouts probably occurred because herbaceous growth was scarce, and the shoots on the uncut oaks were much less succulent than the new sprouts.

- On survey lines cut during the winter of 1953 in the older Plains growth near the Burlington County-Ocean County line, new pine sprouts were closely cropped during the following summer and early fall, but deer only lightly browsed bear oak sprouts, mostly during May and June. Here too there was practically no herbaceous growth available, and no browsing was observed on uncut woody growth.

On the whole, woody browse from tree growth apparently is not a major item in the diet of deer during the growing season; the importance of woody browse from shrubs is questionable; and most browsing so far observed has been on nonwoody plants and on vines, chiefly greenbrier and grape.

September 1 To October 15

Some authors believe that acorns are extremely important in the diet of deer. Both Swift (1946) and Latham (1950) state that good crops of mast, such as acorns, permit deer to build up fat reserves, and thus the animals are better able to survive the winter. Korschgen (1954) concluded from analysis of 440 deer stomachs that acorns comprise 7 to 80 percent of their annual food volume in Missouri, the amount depending on the size of the acorn crop.

In the Pine Region, deer start to feed on acorns about September 1. During one 3-year period, acorns of bear oak and the common tree oaks reached full size about Septem-

ber 1 in the Lebanon Experimental Forest, although they did not begin to fall until late September or early October (Little 1941). However, deer do pick some acorns directly from low scrub oaks.

Tree oaks in most upland stands are relatively young; they produce very small crops of acorns. For example, during a 3-year period observations were made on a few selected trees of white, post, chestnut, scarlet, and black oak in the Lebanon Experimental Forest. Although chestnut oak was the most fruitful species, its acorn crop on stand-grown trees was classed as "none" for 2 years and "light" for 1 year. In contrast, nearby open-grown trees of the same species regularly produced light to heavy crops (Little 1941).

Fruitfulness of tree oaks varies with species. Chestnut oak is regularly the most productive; usually it bears a fair crop of acorns about every other year. Black oak is more erratic. In the Lebanon State Forest, open-grown and large stand-grown black oaks produced heavy crops of acorns in 1941, 1951, and 1955, but very poor crops in many of the intervening years. No heavy seed crops have been observed on white and post oaks in that area for a 20-year period.

Individual trees within a species may differ greatly in fruitfulness. In one study of the acorn production of 55 chestnut oaks near Medford Lakes, 22 of the trees produced no seed during a 3-year period. Ten of these 22 trees were more than 40 years old and resembled nearby seed producers (Wood 1934). Ten-year records on the production of two apparently similar chestnut oaks showed that one tree tended to bear fair to bumper crops in alternate years, little in the other years; the second tree produced very few acorns in any year (McClennen 1939).

Many acorns produced by tree oaks are not available to deer; for example, they may be weeviled or consumed by squirrels, birds, and mice. Wood (1938) noted that as early as August squirrels start to remove acorns, sometimes leaving the cups on the tree to fall later. By using cone-shaped guards to exclude squirrels from isolated trees at Camp Ockanickon, and squirrel-proof traps to catch acorns and acorn cups, Wood concluded that 9 to 50 percent of the acorns may be removed directly from trees--presumably by squirrels.

In the same report Wood told of collecting 1,080 mature cups of chestnut oak acorns, but finding: (1) only 187 germinating acorns, (2) 126 with dried radicles or destroyed by insects and molds; and (3) fragments of 96 that had been partially eaten by animals. Because the soil surface was a labyrinth of mouse burrows and the gray squirrel was very active in that area, Wood concluded that those two animals accounted for most of the acorns destroyed. He also described damage done by mice and squirrels in seedbeds where he had planted acorns, and weevil damage he found most common in acorns of the black oak group.

More data on acorn production and availability were obtained in the Lebanon State Forest in 1952. Then acorns from 12 trees were collected three times a week during the period acorns were falling (up to October 10). Six trees were sprouts 30 years old; the other six were about 70 years old. Each age group was composed of two chestnut oaks, two white oaks, and two black oaks. One of each pair was an open-grown tree; the other was a dominant forest tree. The results are shown in table 2.

Table 2.--Number and condition of acorns collected under twelve open-grown or dominant forest trees, 1952

Tree	Total number of acorns found			Number of sound acorns		
	White oak	Chestnut oak	Black oak	White oak	Chestnut oak	Black oak
30-year-old trees:						
Open-grown	0	19	193	0	10	3
Dominant in stand	0	0	0	0	0	0
70-year-old trees:						
Open-grown	0	139	707	0	55	3
Dominant in stand	0	6	3	0	2	1

If we assume that there are 75 dominant trees per acre in a forest stand equally divided among the three species, and that the average weights of acorns are as given in the Woody-Plant Seed Manual (Forest Service 1948), then the 30-year-old stand might have produced no acorns for deer in 1952; the 70-year-old stand, only 3/4 pound of sound acorns per acre. In contrast, three open-grown trees, one of each

species, would have yielded about 0.13 pound when the trees were 30 years old, and about 3/4 pound when 70 years old.

Evidently deer in the Pine Region obtain little of their diet from the acorns of tree oaks. Acorns often fall within a 4-week period (Little 1941), and few sound ones remain on the ground available for deer beyond the second or third week in October, except in unusual years. Then acorns may be found under open-grown trees (along roads or on the edges of clearings), or under dominants of the oldest stands until much later--occasionally into midwinter. But because of past wildfires and cuttings, such old stands are rare.

Actually, scrub oaks may be a more important source of acorns for deer than tree oaks. Although dwarf chinkapin and blackjack oaks can also be considered scrub oaks, bear oak overwhelmingly predominates in most scrub-oak areas.

Acorn production by bear oaks of different ages was studied in 1952 by collecting all mature acorns from four milacre-quadrats in each of three areas. One had bear oak sprouts 3 years old; another, 7-year-old sprouts; and the third, 30-year-old sprouts. Two of the four quadrats in each area were located where the bear oaks were partly shaded by overstory pines, two where the bear oaks were open-grown. Both bear oaks and dwarf chinkapin oaks sometimes produce mature acorns on sprouts only 3 or 4 years old. However, no acorns were found on the quadrats having 3-year-old stems. Results from the older stands were:

	Acorns found		*Acorns sound*	
	Under shade (No.)	*In open (No.)*	*Under shade (No.)*	*In open (No.)*
Stems--				
7 years old	2	97	0	64
30 years old	36	140	25	98

Since the average sound acorn weighed about 1.23 grams, the scrub-oak areas studied in 1952 would provide the following amounts of sound acorns per acre:

Stems--	*Under shade (pounds)*	*In open (pounds)*
7 years old	0	87
30 years old	34	133

Additional information on the production and availability of scrub-oak acorns was obtained between 1953 and 1955 by collections taken in five typical scrub-oak areas. The sample area for each collection was 10 to 25 milacre-quadrats spaced 100 feet apart. Collections included acorns still on the shrubs and those on the ground. These collections were divided into three classes: (1) sound, (2) weeviled, and (3) in fragments, probably because of mice, squirrels, or birds. The amounts of sound acorns collected in September varied from 4 to 165 pounds per acre. At that time, 51 percent of the acorns in the lightest crop, and 11 percent in the heaviest crop, were weeviled. In October, 93 percent of the whole acorns found in one area where the crop was light were weeviled, and there was only 0.2 pound of sound acorns per acre. The amount of sound acorns collected at this time also decreased rapidly in areas where the crop was heavy. Successive 1954 collections in one tract indicated that the amount available fell from 165 pounds per acre in September to 92 pounds in early October, 38 pounds in late October, and less than 10 pounds in early December. In 1955, the acorn crop was lighter in that area, and only about 1 pound of sound acorns per acre was found there early in December.

Thus, it seems probable that in the Pine Region scrub-oak and tree-oak acorns are part of the diet of most deer for only about 6 weeks in the usual year. Then, either because of poor crops or because trees are too young, most areas produce so few acorns that the supply does not last long. Conditions may commonly resemble those in one area of scrub oak where in late October fragments collected indicated that 66 percent of the acorns had already been consumed by mice or other wildlife, another 32 percent of the acorns were weeviled, and only 2 percent were still sound and available. Some years, acorns are apparently available to deer for several months, but only where oaks, whether tree or scrub, are sufficiently old and dominant to be highly fruitful. Thus the period when deer feed on mast in the

Pine Region is similar to that described by Schilling (1938) for the Pisgah Preserve in North Carolina.

Of course, acorns are not the only food consumed by deer during the time they are available. At least part of their diet comes from browse, mostly from the same types of plants utilized in August, although toward the end of this period, winter-type browse becomes increasingly important.

Effects of Deer on Forest Practices

The authors believe that the detrimental effects of deer browsing constitute a warning that populations of deer now exceed the carrying capacity of the range in some parts of southern New Jersey. As elsewhere, the most desirable browse suffers first and is replaced by less palatable plants. The loss reduces the future carrying capacity of the range; deer destroy their own habitat. This is happening in southern New Jersey wherever overbrowsing favors the replacement of white-cedar by less palatable pines, hardwoods, or shrubs.

Browsing by deer is most detrimental to white-cedar. Small plantings and seedings of this species have been practically wiped out by deer. On the edges of many swamps, white-cedar reproduction is so held in check that it cannot form a part of the stand. And in some areas deer browsing is so heavy that--even in the swamps proper--associated hardwoods and shrubs become the dominant species at the expense of white-cedar, or else the normal rotation required for white-cedar to reach merchantable size is appreciably lengthened. The extent of these harmful effects is not fully known, but it is estimated that they occur on at least 35 percent of the area now in reproduction (trees less than 8 feet tall).

On poorly or imperfectly drained sites and on uplands, deer also exert serious influences on forest management. In

upland oak-pine stands, the effect of deer varies with the amount and size of pine reproduction after cutting.

Deer browsing usually has little effect on the next stand of pine where there is sufficient reproduction more than 1 foot tall after cutting. But when pine reproduction starts after cutting, or where it is less than 1 foot tall at the time of cutting, browsing may lengthen by 2 or 3 years the time required for pines to reach merchantable size. There, deer may also reduce the proportion of pine in the next stand by increasing pine mortality and by handicapping them in competition with hardwoods. This is especially true in areas where pine reproduction is sparse.

In pine-lowland and pine-scrub oak areas, the effect of deer browsing is apparently greater than in oak-pine stands. In pine-scrub oak areas, competing scrub oaks usually so retard the growth of pines that they remain susceptible to browsing for longer periods. There, deer may lengthen the rotation by 5 years and also decrease appreciably the proportion of pine. Present information indicates that similar adverse effects occur in most of the pine-lowland areas.

Effects of Forest Practices on Deer

The objectives of forest management practices are, on the whole, quite desirable for deer. Forestry introduces a pattern of systematic utilization that gives stability to habitat. While forest management may not provide peak forage levels such as those that follow widespread clear-cutting, neither does it produce the lows associated with unbroken stands of old growth. Left to their own devices, deer, by overbrowsing plants of highest palatability, tend to bring about progressive deterioration of their own range.

In the Pine Region, foresters would manage for almost pure stands of white-cedar in true swamps, seedling stands of

pitch pine on the surrounding poorly drained soils, and seedling stands predominantly of pitch and shortleaf pines on upland sites. These objectives may never be completely attained.

All timber stands should be managed as even-aged forests; but the area in a single-age stand will vary--depending on ownership, forest type, and natural boundaries such as roads and swamps. In white-cedar swamps the area covered by one age class might be 5 to 20 acres; on drier sites, usually 20 to 100 or more acres. In large holdings on upland sites, units of about 100 acres seem most desirable for initial management (Little, Allen, and Moore 1948). But in later years even these will probably be divided into units of 20 to 50 acres.

Management measures differ among sites. In true swamps, harvest cuttings should be clear-cuttings; cull hardwoods should be cut, girdled, or poisoned; slash should be burned when dry; and cleanings will usually be necessary for the best stand composition (Little 1950). On some pine lowlands, summer fires may be used just before or after a seed-tree cutting, and cleanings may be desirable in certain portions (Little and Moore 1953). On drier parts of some pine-lowland areas and on the uplands, periodic winter fires should be used when overstory trees are resistant to damage, or are more than 2 inches in diameter on upland sites.

The use of fire should be discontinued before harvest cutting (either seed-tree or shelterwood system, depending on stand density). Cleanings or poisoning of competing hardwoods would be desirable, but are so costly when young oak timber is cut that such stands probably should be grown on a 40- to 70-year rotation. Prescribed burning would be used again after the desired pine reproduction is more than 2 inches in diameter (Little and Moore 1950; Little 1953).

And a definite attempt should be made to develop interspersed stands of varying ages, so that burned and unburned areas will alternate--possibly in a checkerboard fashion (Little, Allen, and Moore 1948). Since fires and past cuttings have tended to create monotype woodlands in the Pine Region, the development of a mosaic in stand conditions will take many years to achieve.

However, such a mosaic should provide a more constant supply of food for deer. According to Allen (1953), deer find the most food in young stands; so having a fairly constant proportion of an area in young stands should help stabilize the food supply. As Bramble and Goddard (1953) pointed out, continuous cuttings, properly distributed, are the key to good range conditions for deer. Swift (1946) has also emphasized the importance of continuous cuttings and of creating edge effects (or a mosaic of conditions). All the data so far obtained in New Jersey are in agreement with these general principles.

There are, of course, regional differences. Many authors in writing about deer in more hilly or northern sections stress "browse lines". These are much more likely to develop in areas with deeper snows and much less ground vegetation than occur in the Pine Region. All our data and observations indicate that deer here feed far more on very low or ground vegetation than they do in the hillier or snowier sections. Some authors like Swift (1946) and Korschgen (1954) stress the importance of agricultural crops in the diet of deer. That would be true of North Jersey, or on the edges of the Pine Region; but within it, where there are few or no farms, crops cannot form much of their diet.

Prescribed burning as advocated by foresters is also considered favorable to maintaining a food supply for deer and to making the forest more accessible to hunters. As Swift (1946) stated for Wisconsin, light burning encourages a new growth of deer food. In the Pine Region, prescribed burning kills back shrubs, small pines, and hardwoods; but many sprout, and new pine seedlings start. And so, in areas periodically burned, there is usually more suitable food than in areas long unburned.

This is particularly true when burning is discontinued and stands are cut. Then pine seedlings, hardwood sprouts, shrub sprouts, sedges, grasses, and other herbs provide the maximum amount of suitable food possible under the usual forest conditions on upland sites. Changes in ground cover associated with burning and cutting have been described by Buell and Cantlon (1953), who noted the large increase in herbaceous cover on areas frequently burned and then cut. Burning, by reducing ground cover, also makes areas more easily traversed by hunters and loggers: pine lowlands and scrub-oak stands are difficult to penetrate

when fires are excluded for 15 years or more.

Prescribed burning may also produce more nutritious food for deer. At least Einarson (1946) found that browse plants in the Tillamook Burn in Oregon contained more protein than those from unburned areas, and that deer taken in the burn averaged greater weights--although present in greater numbers--than those in the surrounding areas. In Georgia, Halls et al. (1952) found that the protein and phosphorus content of forage was higher in burns, particularly in early spring, and that cattle gained more than twice as much in areas burned every 1 to 3 years as in the unburned areas.

We do not have such data for the Pine Region, but observations show that deer do frequent burned areas once new growth is available. Burns (1952) found that prescribed burning tended to result in more nitrogen, calcium, and potassium in the surface soils of this region. Although these elements might make growth in burned areas more nutritious, soils here are so low in nutrients that the physical changes in vegetation--succulent, new woody growth and increases in ferns, sedges, and other herbs--are probably more important than the chemical composition of the growth.

Production of tree-oak acorns would be increased under our recommendation that these oaks be grown to an age of 40 to 70 years. But, because of squirrels and mice, it is questionable whether many of these acorns would be available for deer.

In the long run, an increase in the proportion of pine would reduce the supply of acorns. Still, the year-round benefits associated with more pine would probably more than offset the reduced acorn supply for the short period they are available.

Foresters are attempting to increase the density of pine in scrub-oak areas, and here particularly their objectives and the interests of deer may be in conflict. High stand densities and the use of prescribed fires at, say, 5-year intervals during much of the rotation will reduce the production of scrub-oak acorns. However, it should be remembered that:

- Foresters advocate a mosaic of stand conditions, and hence there would always be some reproduction areas where the scrub oaks fruit abundantly.

- Even on prescribe-burned areas, some scrub oaks will survive and fruit; and on some areas the fuels accumulate so slowly that the interval between fires will be 7 years or longer--long enough for open-grown stems to bear acorns.

- Scrub-oak acorns are evidently a source of food for deer only for a very short period; during the rest of the year, areas under forest management supply far more food than those where scrub oak is fruiting most abundantly.

- Scrub oak is a fire species. Total exclusion of fire would, in time, mean the elimination of scrub oak.

Conflict does exist between forest management and the maximum production of deer, as Swift (1946), Latham (1950), and others point out. And, as in other regions, maximum deer production obviously is not the best land use for the Pine Region of southern New Jersey. Apparently, to attain the most deer on the natural vegetation, all forest land should be in low growth, 6 feet tall or less. Such low growth would eliminate all wood production.

Yet wood production is important to the local economy. In recent years the Pine Region has annually produced about 100,000 cords of wood, mostly pulpwood, worth $2,000,000 delivered at the mills. The mills that depend on local timber are worth about $30,000,000 and employ some 3,000 persons. Other wood products from the Pine Region--lumber, posts, piling, poles and rustic furniture--are estimated to be worth $700,000 annually; and this production provides employment for at least 200 persons. Foresters estimate that, under forest management, the depleted stands in the Pine Region would yield ten times the present production, furnishing products worth about $23,000,000 annually, with proportional increases to industry and labor.

Wildlife, as such, has, according to Webb (1953), a relatively low economic value. Wright (1949) estimated that hunting-club members spent $169,014 annually for transportation, clothes, food and drink, hunting equipment, club membership fees, use of trucks and an occasional guide and other items incidental to their annual deerhunt in the Pine

Region. He also estimated that in one 75-square-mile area 27 percent of the hunters did not belong to hunting clubs. If we assume that a similar ratio of non-club members prevails throughout the Pine Region, that their expenditures are similar to club members, and that these expenditures have increased proportionally with the decline of the dollar in value, then recent expenditures of all deer hunters in the Pine Region may total $280,000 a year. This amount indicates the value of deer hunting to the general economy of the State, but in actual fact, relatively little of this money reaches the private owners of forest land.

Maintaining the maximum number of deer would also conflict with farming in or near the Pine Region, since any increase in deer would doubtless increase damage to crops. Also, maintenance of low-growth forests for deer would certainly have a detrimental effect on woodland values for other forms of recreation--for picnicking, camping, and summer-home sites.

Furthermore, a maximum deer population would doubtless require expensive game-management measures. Yet, according to Webb (1953), costly management for wildlife is difficult to justify unless the cultural work also improves timber. Cultural work he mentions includes cuttings and prescribed burning to produce changes in food and cover. His opinion and Stoddard's (1936) agree with that of the authors--that while maximum game population is incompatible with maximum timber production, much game can be produced on forest lands with minor modifications in forestry practice; and in so doing it is forestry, not game management, that pays most, if not all, of the bill.

Apparently a balanced program will evolve. Since forested areas can produce both timber and deer, such a program can be developed. But it can be achieved only by the mutual efforts of both landowners and hunters.

Summary and Conclusions

This paper is based on observations and studies made in the Pine Region of southern New Jersey since 1928. While investigations dealt mostly with forest trees, observations included other native vegetation.

Food habits of deer in this region were grouped into three major periods:

- During the dormant season, deer feed chiefly on woody browse. Shrubs, vines, and other minor vegetation are then browsed lightly, if at all. Browse from trees is of most importance. On upland sites deer utilize both pines and oaks, but small pitch and shortleaf pines furnish the most food. Tree-oak sprouts are browsed much more than bear-oak sprouts or tree-oak seedlings. The upland sites furnish relatively little food: most of it comes from lowland sites, especially from Atlantic white-cedar.

- During the growing season much of the deer's diet comes from nonwoody plants, and again the lowlands seem to provide the bulk of this diet.

- For one or two months after September 1, acorns are usually an important deer food. The length of this period varies greatly from year to year; but it is usually relatively short since (1) tree oaks in most stands are too young to produce large crops and (2) deer have to compete with weevils, squirrels, birds, and mice for both tree-oak and scrub-oak acorns.

Forestry practices in the Pine Region do much to provide suitable food and cover for deer. On all sites foresters are aiming for a mosaic of stands of different ages, thus providing an interspersion of conditions that should help stabilize game populations. In the swamps, foresters try to grow white-cedar, which is locally the most important winter browse for deer. On drier sites, the use of prescribed burning and harvest cuttings encourages establishment of pine seedlings, herbaceous plants, and sprouts from hardwoods and shrubs, many of which are important deer foods.

Forestry and maximum numbers of wildlife are incompatible, and even now deer are present in certain locali-

ties in sufficient numbers to handicap timber production. On certain sites deer are even reducing the future carrying capacity of the range by overuse of palatable browse; thus, white-cedar is being replaced by less palatable pines, hardwoods, and shrubs. Sustained or increased deer populations under such conditions will have to depend on artificial food supplies from farm crops grown for deer or utilized by them.

The other alternative is to keep deer populations in balance with the natural food supply, increasing this where possible through forestry practices. These practices are not charged to game management, and the increased food supplies and ease of hunting would be subsidiary benefits from forestry activities.

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Appendix

SCIENTIFIC NAMES OF PLANTS MENTIONED

Common Name	*Scientific Name*
Bayberry	*Myrica pensylvanica* Loisel.
Blackberry	*Rubus* spp.
Blackberry, swamp	*Rubus hispidus* L.
Blackgum	*Nyssa sylvatica* Marsh.
Blueberry, highbush	Chiefly *Vaccinium corymbosum* L.
Blueberry, lowbush	Chiefly *V. vacillans* Torr.
Blue flag	*Iris prismatica* Pursh
Broom-sedge	*Andropogon* spp.
Cranberry	*Vaccinium macrocarpon* Ait.
Creeper, Virginia	*Parthenocissus quinquefolia* (L.) Planch.
Fern, bracken	*Pteridium aquilinum* (L.) Kuhn
Foxglove, false	*Gerardia pedicularia* L.
Grape	*Vitis* spp.
Greenbrier	*Smilax rotundifolia* L.
Hawthorn	*Crataegus* spp.
Hickories	*Carya* spp.
Huckleberries	*Gaylussacia baccata* (Wang.) K. Koch and *G. frondosa* (L.) T. & G.
Indigo, wild	*Baptisia tinctoria* (L.) R. Br.
Juneberry	*Amelanchier* sp.
Leatherleaf	*Chamaedaphne calyculata* (L.) Moench
Maple, red	*Acer rubrum* L.
Oaks:	
Bear	*Quercus ilicifolia* Wangenh.
Black	*Q. velutina* Lam.
Blackjack	*Q. marilandica* Muenchh.
Chestnut	*Q. prinus* L.
Dwarf chinkapin	*Q. prinoides* Willd.
Post	*Q. stellata* Wangenh.
Scarlet	*Q. coccinea* Muenchh.
Southern red	*Q. falcata* Michx.
White	*Q. alba* L.
Pea, hoary	*Tephrosia virginiana* (L.) Pers.
Pepperbush	*Clethra alnifolia* L.
Pine, pitch	*Pinus rigida* Mill.
Pine, shortleaf	*P. echinata* Mill.
Pine, Virginia	*P. virginiana* Mill.
Pinweed	*Lechea racemulosa* Michx.
Rose	*Rosa* spp.
Sassafras	*Sassafras albidum* (Nutt.) Nees
Sedge	Chiefly *Carex* spp.
Spicebush	*Lindera Benzoin* (L.) Blume
Sumac, dwarf	*Rhus copallina* L.
Sweetbay	*Magnolia virginiana* L.
Sweetfern	*Comptonia peregrina* (L.) Coult.
Turkeybeard	*Xerophyllum asphodeloides* (L.) Nutt.
White-cedar, Atlantic	*Chamaecyparis thyoides* (L.) B.S.P.
White-cedar, northern	*Thuja occidentalis* L.